PRACTICE SHARING

FCC Non-Routine Operations Standby Checklist

Purpose and Use:

The purpose of this document is to share the practice of providing Fluid Catalytic Cracker (FCC) Operations teams with a list of monitoring activities and frequency to be performed while the unit is in a non-normal/standby operating mode. This list will be referred to as a "Standby Checklist" and supplements standard operating procedures such as the procedure for transitioning the unit from routine operating conditions to a non-routine/standby mode. Under this practice, FCC Unit leaders prepare clear guidance, in advance, on the important monitoring parameters during non-routine operating mode, including intended target values for those conditions in order to reduce the risk of:

- Flow of hydrocarbon back from the main fractionator to the regenerator via the reactor, and
- Flow of air from the regenerator to the main fractionator and downstream via the reactor.

Either of the above can result in accumulation of a flammable mixture that could result in an explosion. A Standby Checklist includes important monitoring parameters developed in advance by key operating process personnel and provides guidance on ongoing operation following the execution of the FCC Standby Procedure or other operational event that results in a non-normal operating mode such as a unit SIS (Safety Instrumented System) trip.

Practice Sharing Documents are meant to share information on process safety practices in order to help improve process safety performance and awareness throughout industry. The goal is to capture and share knowledge that could be used by other companies or sites when developing new process safety practices or improving existing ones. The Practice being shared has been used by an industry member, but this does not mean it should be used or that it will produce similar results at any other site. Rather, it is an option to consider when implementing or adjusting programs and practices at a site.

BY THEMSELVES, THE PRACTICE SHARING DOCUMENTS ARE NOT STANDARDS OR RECOMMENDED PRACTICES. THEY ARE NOT INTENDED TO REPLACE SOUND ENGINEERING JUDGMENT. THEY DO NOT PRECLUDE THE USE OF ALTERNATIVE METHODS THAT COMPLY WITH LEGAL REQUIREMENTS. A SUBJECT MATTER EXPERT SHOULD BE CONSULTED PRIOR TO DETERMINING WHETHER A PRACTICE SHARING DOCUMENT CAN BE USED IN ANY SPECIFIC SITUATION.

Scope:

This Practice Share document applies to FCC units once they have transitioned to standby or non-routine operating conditions. This can be a planned transition from normal operating conditions, the result of a unit trip, or part of a unit startup or shutdown. The practice outlines the importance of providing guidance for users to consider developing a checklist of operating conditions and monitoring parameters during non-routine operations. Key operating parameters can be organized in tables, checklists, documented operator rounds, written procedures, or other formats along with a frequency for collection of the corresponding information. Equally important is explaining the reason why the specific operating parameter is included and the implications of the parameter being outside the acceptable range.

Description:

The document clearly outlines what constitutes standby or non-routine operation to eliminate confusion about when the transition procedure and additional variables to include in unit monitoring per the non-routine operations Standby Checklist apply. A list of general process variables and equipment status is provided that can be incorporated into a unit specific monitoring plan. This is followed by suggestions on the implementation including personnel requirements and documentation formats.

Operation Modes:

An example definition of "Standby Operation" is "Feed out of the riser and the reactor is not isolated from the main fractionator. Catalyst may be circulating with slide valves open or slide valves may be closed. Main Air blower and Wet Gas compressor may be in service or shutdown."

In Start-up, this practice share applies at the point the main fractionator isolation valve is opened or the blind is removed and usually ends once circulation is stable, and feed is introduced.

In Shutdown this practice share applies once feed is removed from the unit and continues until the main fractionator is isolated.

Other non-normal operation modes include unstable operation due to a unit upset or emergency condition.

Depending on the unit configuration, a unit without feed, but having stable catalyst circulation may not be considered in Standby Operation. If the main fractionator hydrocarbons are isolated from the reactor the checklist does not apply and the unit is not considered in Standby Operation for the purposes of this practice share.

Implementation of the Standby Checklist monitoring is performed by support personnel who are responsible for daily operations of the unit.

Monitoring Plan:

The parameters to be included in the standby checklist will vary based upon the FCC configuration and design parameters and typically includes a description of each parameter, expected range, and implications of being out of range as a refresher to operator training or detailed procedures. The following guidance is provided for users to consider in developing an appropriate checklist for their FCC unit.

<u>Standby Operations Suggested Process Parameters</u>

- Specify some of the instrument locations, such as for differential pressure.
- Provide a description of typical monitoring variables.
- Field verification of slide valve / plug valve positions and frequency of rechecking these positions.
- Field verification of isolation points of hydrocarbon sources to the reactor.
- Specify checking Reactor and Regenerator differential pressure.
- Specify checking Reactor and main fractionator differential pressure.
- Specify Slide / Plug valve dP limits. Identify differences from normal pressure monitoring. It should be noted that normal pressure indicators (both catalyst level indications and slide valve/plug valve dPs) may not provide a representative indication when catalyst is not circulating.
- Specify temperature monitoring and differentiate circulation with torch oil vs. circulation without torch oil, or without catalyst circulation. Include specific concerns on reactor cooling.
- Specify water checks at low points in the reactor and main column pumparound circuits, to monitor for effective removal of steam condensate.
- Specify source and rate of aeration mediums depending on the operating configuration. If steam circulating, aeration may have to be optimized to obtain good fluidization.

FCC Non-Routine Operations Standby Checklist

- Specify means of detecting build-up of oxygen and response to it. (Refer to a separate Practice Share document titled "FCC Reactor O_2 Monitoring")
- Any water that remains in the reactor stripper will flash to steam in the hot lower regenerator and can lead to rapid particle breakdown and high opacity out the FCC stack.

Items to Consider in Standby Mode:
Timing and Duration – When the FCC is expected to remain in a Standby mode for a longer period of time (>1 week):

- Consider isolation of the main fractionator from reactor.
- Consider de-inventorying catalyst from regenerator if parking the unit for an extended period (> 2 weeks). Catalyst should not be kept in reactor. Continue purges on instrumentation and distributors to prevent plugging.
- Consider possible freezing conditions and internals subjected to freezing conditions (winter specific).
- Prior to re-starting, the unit is thoroughly checked for the presence of water, which is removed.

While in Standby mode without isolation of the main fractionator from the reactor, consider the following operating parameters and conditions:

- Steam/Sour Water Management – When the Reactor and main fractionator are open to each other, sour water production and steam flows/reactor temperatures are monitored frequently to ensure forward flow of steam from reactor through the main fractionator; if catalyst is not flowing, standpipe temperatures and vessels pressures are monitored to ensure proper direction of steam flow.
- Main fractionator pressure control valve output – If applicable, the output on the main frac accumulator flare valve (PCV) is monitored to ensure that gas is flowing forward towards the main fractionator.
- Reactor/Regenerator Temperature Management – If catalyst circulation is stopped for any reason the reactor will begin to cool. Evaluate the possibility of batch catalyst circulation from the regenerator to the reactor to maintain reactor temperature above steam condensation temperature to prevent plugging including the increased risk of reactor catalyst losses. If not batch circulating, consider emptying all catalyst to regenerator. If the Reactor is allowed to cool, manage steam condensate in reactor and risk of plugging.
- Consider closing isolation valves around pumparound exchangers in heat exchange or reboiler service with light ends material. These may include deethanizer, depropanizer, and debutanizer reboilers. If these exchangers have tube leaks, even if pumparound pumps are not running, volatile light hydrocarbons can enter the main fractionator and become a source of hydrocarbon vapor that may backflow into the reactor/regenerator if other barriers fail.

Implementation:

Checklists provide a time-based expectation for review of items covered, typically at least 1 time per shift. Results are documented in a refinery data logging system.

If non-routine operations linger until shift change, the use of an FCC Specific shift handover checklist for non-routine operations may reduce the likelihood of incomplete communications resulting in human error. A Walk The Line video on Operational Continuity, Chapter 6, and a WTL Shift Handover video is available at https://safetyportal.afpm.org/initiatives/ and a Practice Share document for a Shift Handover during FCC Non-routine Operations is available at https://safetyportal.afpm.org/File/1713/1 on the Safety Portal to supplement use of the practice covered in this document.

The following are examples of various Process Parameters, which is not a complete list and may vary from unit to unit. Provided is the standby scenario of concern, monitoring recommendation, potential actions, and any additional notes.

Sour Water Production
Checking the sour water produced off the main fractionator overhead accumulation drum is a method of verifying that the steam entering the riser is travelling through to main fractionator and that backflow of hydrocarbon from the main fractionator to the reactor is not occurring.

- Tag # measures the total sour water produced off the main fractionator overhead accumulation drum. This value should exclude wash water recycle and any other miscellaneous sour water flows. A target value for this flow rate should be provided that indicates that sufficient reactor steam is reaching the main fractionator overhead accumulation drum.
- Tag # controls the main fractionator overhead accumulation drum boot level. This tag # process value and output is monitored to verify that they are remaining steady. A falling output or erratic process value could indicate that reactor steam is not reaching the main fractionator overhead accumulation drum.
- Tag # monitors main fractionator temperature(s) and ensures tower is hot enough for water to travel up tower to overhead accumulator.

Main Fractionator Overhead Drum Pressure and Temperature
Reactor pressure and the main fractionator overhead temperature are other methods of identifying that reactor purge steam and/or nitrogen is reaching the main fractionator overhead accumulation drum.

- Tag # controls the main fractionator overhead accumulation drum pressure to flare. This tag # process value and output are monitored to verify that they remain steady. A falling process value or output could indicate that reactor steam is not reaching the main fractionator overhead accumulation drum.
- Tag # measures main fractionator overhead temperature. This temperature is monitored to verify that it remains steady. A falling temperature could indicate that reactor steam is not reaching the main fractionator overhead accumulation drum.

Slide Valve dP – During Catalyst Circulation
When circulating catalyst, it is important to maintain a dP to prevent backflow of either hydrocarbon or air between the reactor and regenerator vessels. This is true during normal operation and remains true during Standby operation.

It is important to understand your unit pressure balance to determine a safe minimum slide valve or plug valve dP, as this dP is impacted by more than just the head of catalyst in the standpipe. Reactor/regenerator differential pressure and transfer line dP downstream of the slide valve (lift riser, spent cat distributor, etc.) will impact the measured slide valve dP. A standpipe dP, measuring from above the slide valve to the vessel freeboard, can be monitored, in addition to the slide valve dP.

Without reactor feed, the pressure balance within the FCC is altered and therefore the slide valve dPs are altered. This may create an increased risk of the dPs providing false readings.

- Review RCSV (Tag #) output trend and RCSV dP (Tag #) process value trend to verify that they are stable. Review the slide valve differential pressure (Tag #s) trends and verify their match with the valve outputs and process values.
- Review the SCSV (Tag #) output trend and RCSV dP (Tag #) process value trend to verify that they are stable. Review the slide valve differential pressure (Tag #s) trends and verify their match with the valve outputs and process values.
- If monitored, review the standpipe dP (Tag #) process value trend to verify that it is stable.
- Verify the position of slide valves (Tag #s) in the field matches their position shown on the DCS.
- Review trend of reactor pressure (Tag #) and regenerator pressure (Tag #) to verify that they are tracking together.

Practice Sharing

FCC Non-Routine Operations Standby Checklist

Slide Valve Position – No Catalyst Circulation

If operating in a mode where the catalyst circulation is not maintained, the slide valves will be closed. It is important to verify the slide valves are closed in the field. If the slide valve is not fully closed there is a risk of hydrocarbon or air backflow between the regenerator and reactor vessels. Slide valve dP values become less representative of catalyst head above the slide valve when slide valves are closed.

- Verify that the RCSV and SCSV are fully closed on the positioner in the field.

Catalyst Bed Levels

If the pressure balance is not working as desired there is a risk of moving all the catalyst to the Regenerator or Reactor leaving no catalyst to help restrict flow between the reactor and regenerator thus enabling significant hydrocarbon or air backflow between the regenerator and reactor vessels.

- Review the regenerator dense bed levels, (Tag #s). Verify that the trends track together and are not continuously building or falling.
- Review Spent Catalyst bed level, (Tag #) process value. Verify that the trend is not continuously building or falling. Verify that the spent catalyst bed level (Tag #) process value and output trend together.
- During non-routine operation, fluid catalyst bed level indications may become erratic due to pressure, temperature, and fluidization differences from normal operation.

Hydrocarbon isolation

- Confirm that all hydrocarbon feed is isolated from the reactor (field confirm that it is double blocked away from the riser). This applies to fresh feed, recycle, slop connections, and hydrocarbon lift gas if utilized.
- If not firing torch oil, ensure torch oil flow is isolated from regenerator (double blocked and air gapped).

Inert gas flow rates

- Steam and/or nitrogen rates are according to procedure targets. Nitrogen is often supplied from trucks via hose, so a checklist is used to verify that hose connections are in place at specified areas.

Main Fractionator Bottoms Level

- Confirm that main fractionator bottoms level is within the instrument range, because without the overhead blind in place feed typically circulates through the slurry pumparound. Note that the bottoms level instrument is likely calibrated for a higher density than the feed density circulating in standby operation. It therefore may go off range at considerably less than 100%.
- During non-routine operations, main fractionator bottoms operation may become erratic due to low temperatures and the presences of water.

FCC Non-Routine Operations Standby Checklist

Standby Checklist Example

An example Standby Checklist is provided below in Table 1. For this checklist DCS parameters are monitored every four hours and field checks are made twice per shift. Examples of the general parameters to be recorded on the checklist are provided.

Table 1: Standby checklist in table form

Parameter	Tag	Target	TIME														
Spent or Regen Slide / Plug Valve %OP	Tag #	Stable, trends with the valve's dP	**%OP**														
Spent or Regen Slide / Plug Valve %OP positioner	N/A	Consistent with its OP	**PV=**														
Spent or Regen Slide / Plug Valve dP	Tag #1 Tag #2 Tag #3 Tag #4	Stable, pressures track together	**Y/N**														
Check group of unit specific differential pressures	Tag #1 Tag #2 Tag #3 Tag #4	Stable, pressures track together	**Y/N**														
Reactor or Regenerator Pressure	Tag #	Stable trend	**Y/N**														
Reactor or Regenerator Bed Level	Tag #1 Tag #2	Stable, tracking together	**Y/N**														
Reactor or Regenerator Bed Level %OP	Tag #1 Tag #2	Stable, PV tracking with OP	**PV=**														
Check Unit Specific Process Variable (PV)	Tag #	Target Value or operating range	**PV=**														
Check Unit Specific Situational	Tag #	Target Value 2 or operating range	**Y/N**														
Check Unit Specific PV and valve output for stable operation	Tag #	PV and OP stable	**Y/N**														
Check Unit Specific Stable PV	Tag #	PV Stable	**Y/N**														

To facilitate the user's application of this practice to their own unit an example Standby checklist is provided below for use as a starting point for generation of their own unit specific checklist.

Practice Sharing

FCC Non-Routine Operations Standby Checklist

References:

Hazard Identification Document on Flammable Mixture Accumulation in FCC units in the AFPM Safety portal available at https://safetyportal.afpm.org/File/1652/1.

Safety Bulletin on Accumulation of Flammable Mixtures in FCC units in the AFPM Safety portal available at https://safetyportal.afpm.org/File/1650/1.

Practice Sharing document on Simplified DCS Screen for Non-routine FCC Operations in the AFPM Safety portal available at https://safetyportal.afpm.org/File/1676/1.

Practice Sharing document on FCC Reactor O2 Monitoring in the AFPM Safety portal available at https://safetyportal.afpm.org/File/1712/1.

Practice Sharing document on Shift Handover Checklist while in Standby Operations in the AFPM Safety portal available at https://safetyportal.afpm.org/File/1713/1.

Revision	Date	Summary of Changes
Initial Draft	October 2021	Initial Version
Revision	November 2021	HIPS Review
Revision	January 2022	PSW Review
Legal Review	April 2022	AFPM Legal Review
Final	April 2022	Published

Note: This practice sharing document in no way alters any legal requirements. It is not intended to replace sound engineering analysis or judgment.